ZooKeys 473: 119–136 (2015)
doi: 10.3897/zookeys.473.8956
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Distribution of *Benthesicymus tanneri* Faxon, 1893 (Dendrobranchiata, Benthesicymidae) off the west coast of Mexico and notes on its morphology

Michel E. Hendrickx[1], Vanesa Papiol[1]

1 *Laboratorio de Invertebrados Bentónicos, Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, P.O. Box 811, Mazatlán, Sinaloa, 82000, Mexico*

Corresponding author: *Michel E. Hendrickx* (michel@ola.icmyl.unam.mx)

Academic editor: *S. De Grave* | Received 15 November 2014 | Accepted 11 December 2014 | Published 20 January 2015

http://zoobank.org/9E1F8D5C-90C9-452D-AED8-01B73772A0AA

Citation: Hendrickx ME, Papiol V (2015) Distribution of *Benthesicymus tanneri* Faxon, 1893 (Dendrobranchiata, Benthesicymidae) off the west coast of Mexico and notes on its morphology. ZooKeys 473: 119–136. doi: 10.3897/zookeys.473.8956

Abstract

A large series of specimens of *Benthesicymus tanneri* Faxon, 1893 (Dendrobranchiata; Benthesicymidae) was collected during an extensive survey of deep-water invertebrate fauna off western Mexico. In total, 61 males and 122 females (M:F ratio = 1:2) from 44 sampling stations were examined, considerably increasing the number of known specimens and sampling localities for this species which is widely distributed along the Pacific coast of Mexico. The collection is the largest available for this species to date and presents first records from off the west coast of the Baja California Peninsula and a slight increase of the northernmost record within the Gulf of California. On the whole, females grew larger than males. The petasma of males of different sizes and the female thelycum of *B. tanneri* are illustrated. The petasma of *B. tanneri* presents a ventrolateral crescent-shape process otherwide found only in *B. tirmiziae* Crosnier, 1978 and in *B. bartletti* S.I. Smith, 1882. A key to the four species of *Benthesicymus* presently known from the eastern Pacific is presented.

Keywords

Benthesicymus tanneri, eastern Pacific, distribution, key to species

Copyright *Michel E. Hendrickx, Vanesa Papiol.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Benthesicymidae is a relatively large family of shrimps that contains 39 species within five genera. The most species-rich genera are *Gennadas* (16 species) and *Benthesicymus* (15 species) (De Grave and Fransen 2011). The genus *Benthesicymus* was first reviewed by Burkenroad (1936) when the group comprised 19 species. However, since then several of those species have been considered junior synonyms or assigned to different genera, and three new species have been described (see De Grave and Fransen 2011). Burkenroad (1936) separated the 19 species known at that time into two groups (Groups I and II) taking into consideration a long series of characters, including the shape of the exopod of the first maxilliped, the merus of the second maxilliped and the dactyl of the third maxilliped, the relative size of the exopodite of the pereiopods, the position of the pterygostomial spine, and the shape of the pterygostomial carina. In addition, he also considered the structure of the petasma and thelycum. According to Burkenroad (1936), the type species of *Benthesicymus*, *B. crenatus* Spence Bate, 1881, is part of Group I. The two groups (I and II) are essentially the same as those referred to by Kikuchi and Nemoto (1991) and Dall (2001), but these authors used a reduced series of characters and an updated list of species. Kikuchi and Nemoto (1991), however, ommitted *B. cereus* Burkenroad, 1936, from their list and key, and included *B. longipes* Bouvier, 1906 (now synonymized with *B. iridescens* Spence Bate, 1881) and *B. brevirostris* Kikuchi & Nemoto, 1991 (now transferred to the genus *Altelatipes*). Dall (2001) cited the 15 species from the Indo-West Pacific known to him, including *B. brevirostris* and *B. longipes*, and provided a key to species from that region.

Characters used by Kikuchi and Nemoto (1991) in their definition of Group I and II included the position of the branchiostegal spine, the shape of the second maxilliped and of the dactylus of third maxilliped, and the relative size of pereiopods' exopod. Their Group II includes five species, two of which have been recorded in deep waters of the Mexican Pacific: *B. altus* Spence Bate, 1881, and *B. tanneri* Faxon, 1893 (see Hendrickx 1996). Although similar in their general shape, *B. altus* and *B. tanneri* are easy to separate based on the structure of the thelycum and petasma. Kikuchi and Nemoto's (1991) Group I included 10 species, one of them also reported off western Mexico, *B. laciniatus* Rathbun, 1906, which distinctively features small spines on the posterolateral margin of the fifth abdominal somite.

To date, four species have been certainly recorded in the eastern Pacific. *Benthesicymus altus* is distributed from California, USA, to the Galapagos Islands, but it also occurs in the Atlantic and Indo-Pacific (Guzmán and Wicksten 2000). *Benthesicymus tanneri* is known from California, USA, and the Gulf of California (north to 27°34'N; 110°53'W), Mexico, to Chile (21°19'S) (Retamal and Soto 1993; Wicksten and Hendrickx 2003). The taxonomic status of *B. laciniatus* Rathbun, 1906, was reviewed by Wicksten (2004) and this species is known from Hawaii, Santa Catalina Island (as *Gennadas pectinatus* Schmitt, 1921, a junior synonym of *B. laciniatus*), California, USA, and off Baja California Peninsula (31°20'N; 120°8'W) (Wicksten 2004). Another species of Group II, *B. investigatoris* Alcock & Anderson, 1899, is widely distributed in

the world oceans and has been reported in the eastern Pacific off Chile (Salas y Gómez Island and Ridge; Nazca Ridge) by Retamal and Moyano (2010). There is an additional record for a fifth species of *Benthesicymus* in the eastern Pacific, *B. crenatus*, but this record is based on a tentative identification by I. Peréz-Farfante ("*Benthesicymus* cf. *crenulatus*", USNM 216490) from a specimen collected next to the Cortés Bank (32°08'N; 120°48'W; 3782 m depth) and it is doubtful considering that all records for *B. crenatus* are in the northwestern and central Pacific Ocean (Jamieson et al. 2009).

Benthesicymus tanneri is a moderate large species, with females reaching up to 99 mm total length (Hendrickx 1996) and a maximum known size of 112 mm (Faxon 1893). Material examined by Faxon (1893) was collected in 22 "Albatross" stations, from off Ecuador (3°56'N; 81°40'15"W) to the Central Gulf of California (27°34'N; 110°53'40"W), in a depth range from 385 to 1322 fathoms (ca 704–2,427 m depth). Because it is a deep-water species, records after those presented by Faxon (1893, 1895) are scarce and several authors have only repeated previous literature records or geographic distribution (e.g., Schmitt 1921, Rodríguez de la Cruz 1987, Wicksten 1989, Wicksten and Hendrickx 1992, 2003, Hendrickx 1993, 1995, Guzmán and Wicksten 2000). Rathbun (1904: 147) was the first to report on additional material collected by the "Albatross" off San Diego, within the Gulf of California, and off Ecuador, including the Galapagos Islands (Sts. 2923, 2929, 3009, 3010, 2792, 2793, 2808, 2818; from 331 to 1322 fathoms). In her monograph on shrimp from Peru, Méndez (1981: 31) included a large series of samples collected from a very wide latitudinal range (i.e., 3°31'S to 18°17'S) between 500 and 1300 m depth. Kameya et al. (1997) reported *B. tanneri* in three stations off Peru, Retamal and Jara (2002) cited it from off Chile, and Cornejo-Antepara (2010) from off Ecuador. It is also known from off Costa Rica (Vargas and Wehrtmann 2009) and off El Salvador (J. López, pers. comm.).

Material collected in Mexican waters during the TALUD cruises III-VII (1991–2001) in the SE Gulf of California was reported by Hendrickx (2001) and Hendrickx (2004; distribution maps), adding many new records and increasing the known distribution range of this species. A large series of specimens, however, was collected during subsequent research cruises off the Pacific coast of Mexico and has not yet been reported. This series is included herein. This contribution provides and updated distribution of *B. tanneri* for the Mexican Pacific and new data related to the petasma and thelycum of this species. Additionally, a taxonomic key for the species occurring in the American Pacific is provided.

Material and methods

The material on which this study is based was collected by the R/V "El Puma" of the Universidad Nacional Autónoma de México (UNAM), between 1991 and 2014. Specimens of *Benthesicymus tanneri* were captured during sampling operations off the west coast of the Baja California Peninsula (TALUD XV, July-August 2012; TALUD

XVI-B, May-June 2014), in the Gulf of California (a total of nine cruises: TALUD III, September 1991; TALUD IV, August 2000; TALUD V, December 2000; TALUD VI, March 2001; TALUD VII, June 2001; TALUD VIII, April 2005; TALUD IX, November 2005; TALUD X, February 2007), and off the SW coast of Mexico, from Jalisco to Guerrero (TALUD XII, March-April 2009). During these cruises, a total of 228 localities were sampled, from 377 to 2394 m depth. Positional coordinates for each sampling station were obtained using a GPS navigation system. Depth was measured with an EdoWestern analogic recorder (TALUD III-VIII) or a digital recorder (TALUD IX-XVI-B). All the specimens were captured with benthic gear, including an Agassiz dredge (2.5 m width, 1 m high) and a standard benthic sledge (2.35 m width, 0.9 m high), both equipped with a modified shrimp net (ca 5.5 cm stretched mesh size) with a ca 2.0 cm (3/4") internal lining net. The material collected during this survey is deposited in the Regional Collection of Marine Invertebrates (EMU), at UNAM in Mazatlán, Mexico. The size (carapace length, CL) of all the specimens was measured to the nearest 0.1 mm and size distributions of *B. tanneri* were explored by sex for the entire population sample in the Mexican Pacific. Sexual differences in CL were tested using a Mann-Whitney *U* test (Mann and Whitney 1947). Abbreviations are: St., sampling station; CL, carapace length; M, male; F, female; AD, Agassiz dredge; BS, benthic sledge.

Results

Benthesicymidae Wood-Mason, 1891

Benthesicymus tanneri Faxon, 1893

Figures 2–6

Material examined. Specimens of *B. tanneri* were collected in 44 of the 228 stations visited during the survey (Figure 1).

TALUD III. Material reported by Hendrickx (2001). Additional material. St. 14A (24°38'48"N; 108°26'54"W), Aug 19, 1991, 1M (CL 32.5 mm), AD, 1016–1020 (EMU-4418); St. 14B (24°39'12"N; 108°37'48"W), Aug. 19, 1991, 1F (CL 31.9 mm), AD, 1188–1208 m (EMU-2609); St. 17 (24°33'0"N; 108°50'54"W), Aug 19, 1991, 1M (CL 22.1 mm), AD, 770 m (EMU-4417); St. 24A (25°45'12"N; 109°46'48"W), Aug 24, 1991, 2M (CL 29.0–30.8 mm), AD, 1027–1060 m (EMU-100).

TALUD IV. Material reported by Hendrickx (2001).

TALUD V, St. 5 (22°0'57"N; 106°40'0"W), Dec 13, 2000, 1F (CL 36.3 mm), BS, 1515–1620 m (EMU-5540-A); St. 6 (22°N; 106°48'5"W), Dec 13, 2000, 1F (CL 41.1 mm), BS, 1950–2010 m (EMU-5540-B); St. 19 (23°17'30"N; 107°29'51"W), Dec 15, 2000, 1M (CL 31.1 mm), 3F (CL 29.1–36 mm), BS, 1180–1200 m (EMU-5523-A); St. 26 (24°15'18"N; 108°24'6"W), Dec 16, 2000, 2M (CL 29–30.7 mm), 2F (CL 32–34.2 mm), BS, 1280–1310 m (EMU-5523-B).

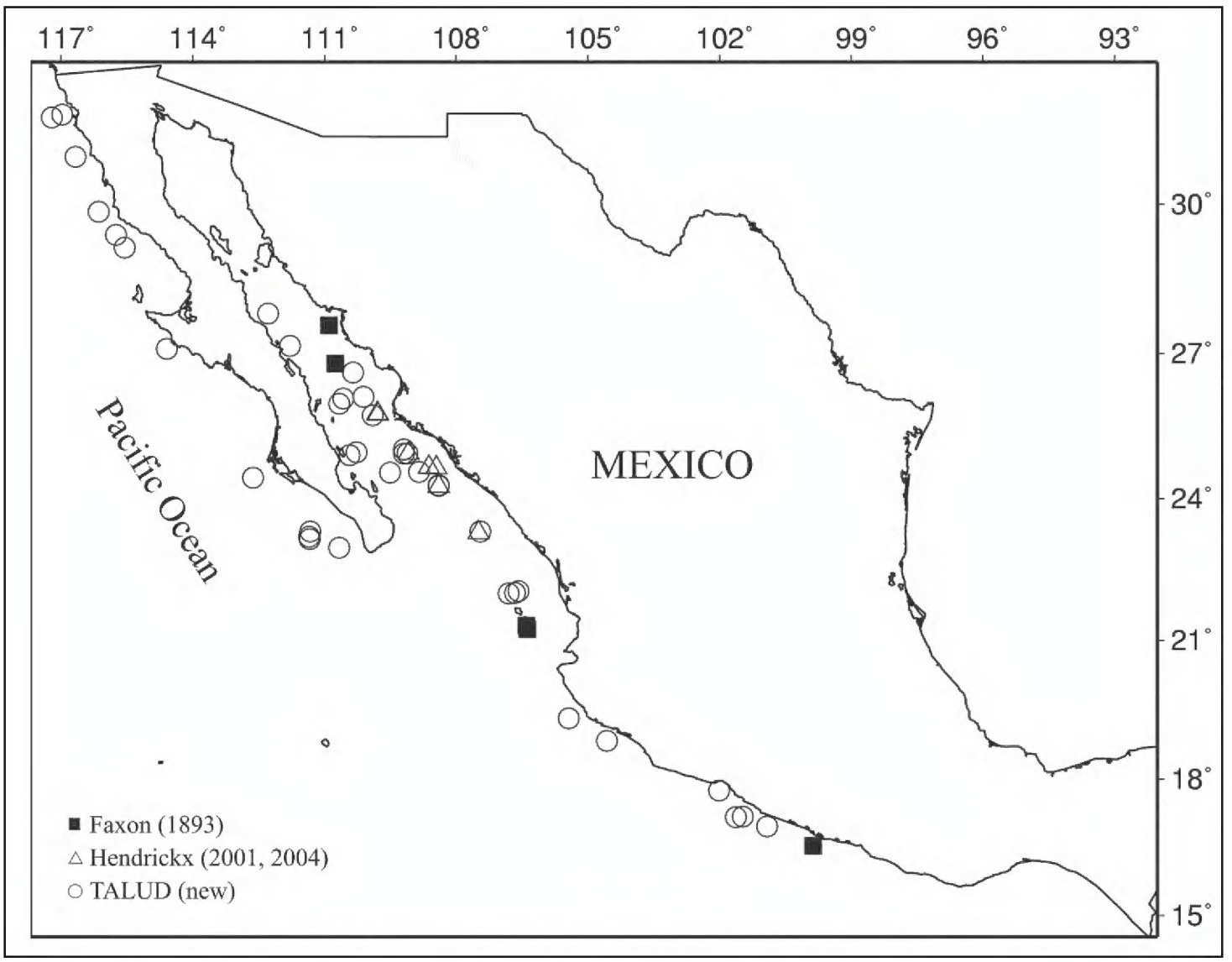


Figure 1. Localities in the Mexican Pacific where *Benthesicymus tanneri* Faxon, 1893 has been collected, including the TALUD project sampling stations and the localities corresponding to the type material collected during the "Albatross" cruises and used by Faxon (1893).

TALUD VI, St. 12 (23°18'36"N; 107°26'56"W), Mar 14, 2001, 1M (CL 32.5 mm), 1F (CL 34.8 mm), BS, 1050–1160 m (EMU-5539-A); St. 19 (24°16'24"N; 108°24'18"W), Mar 15, 2001, 1F (CL 50.4 mm), BS, 1160–1200 m (EMU-5539-B); St. 26 (24°56'18"N; 109°6'42"W), Mar 16, 2001, 1M (CL 33.4 mm), 1F (CL 25.2 mm), BS, 1190–1270 m (EMU-5997-A); St. 27 (25°1'12"N; 109°11'36"W), Mar 16, 2001, 1F (CL 32.3 mm), BS, 1580–1600 m (EMU-5539-C); St. 34 (25°43'50"N; 109°53'59"W), Mar 17, 2001, 1M (CL 31.9 mm), 2F (CL 3025–33.6 mm), BS, 1240–1270 m (EMU-5997-B), and 7M (CL 31.4–34.8 mm), 12F (CL 30.5–42.5 mm), and 3 unsexed specimens (14.5–21.4 mm).

TALUD VII, St. 4 (22°3'18"N; 106°34'42"W), Jun 5, 2001, 1F (CL 37.8 mm), BS, 1190 m (EMU-5541); St. 19 (24°16'12"N; 108°23'42"W), Jun 7, 2001, 1M (CL 11.2 mm) and 1F (CL 34.7 mm), BS, 1160–1180 m (EMU-6004-A); St. 33B (26°6'30"N; 110°6'42"W), Jun 9, 2001, 1F (CL 23.0 mm), BS, 1260–1300 m (EMU-6004-B).

TALUD VIII, St. 10 (24°58'12"N; 110°16'6"W), Apr 17, 2005, 1M (CL 30.4 mm), and 1F (CL 11.2 mm), BS, 1500 m (EMU-8143); St. 3 (24°32'36"N; 109°30'30"W), Apr 16, 2005, 2M (CL 31.9–34.7 mm), 3F (CL 29.2–35.7 mm), BS, 1100 m (EMU-8147).

TALUD IX, St. 20B (25°58'7"N; 110°40'4"W), Nov 14, 2005, 2F (CL 33.7–36.2 mm), BS, 1229–1343 m (EMU-8236).

TALUD X, St. 10 (27°50'5"N; 112°10'7"W), Feb 10, 2007, 1F (CL 32.3 mm), BS, 1399–1422 m (EMU-8030); St. 18 (27°9'6"N; 111°46'54"W), Feb 12, 2007, 1F (CL 31.3 mm), BS, 1526 m (EMU-8118); St. 30 (26°36'50"N; 110°21'10"W), Feb 15, 2007, 1M (CL 29.9 mm), BS, 1203–1213 m (EMU-8203).

TALUD XII, St. 5 (16°58'28"N; 100°55'20"W), Mar 28, 2008, 1F (CL 53.3 mm), BS, 1925–1977 m (EMU-8872); St. 9 (17°10'15"N; 101°37'23"W), Mar 28, 2008, 6F (CL 30.1–35.3 mm), BS, 1392–1420 m (EMU-8874); St. 10 (17°11'18"N; 101°28'30"W), Mar 29, 2008, 3F (CL 21.1–38.7 mm), BS, 1180–1299 m (EMU-10500); St. 13 (17°45'16"N; 102°0'29"W), Mar 30, 2008, 1F (CL 30 mm), BS, 1198 m (EMU-8904); St. 28 (18°50'19"N; 104°34'14"W), Apr 2, 2008, 1F (CL, 38.1 mm), BS, 1101–1106 m (EMU-10499); St. 29 (19°19'37"N; 105°26'20"W), Apr 2, 2008, 1F (CL 44.7 mm), BS, 1609–1643 m (EMU-8873).

TALUD XV, St. 1 (23°18'40"N; 111°19'37"W), Aug 4, 2012, 1F (CL 40.2 mm), BS, 750–850 m (EMU-10435); same station, 5M (CL 17.9–29.1 mm) and 7F (CL 25.3–41.1 mm), BS, 750–850 m (EMU-10434); St. 2 (23°12'2"N; 111°20'50"W), Aug 4, 2012, 4M (CL 32–33.9 mm), 5F (CL 23.2–40.6 mm) and 1Juv. (CL 12.4 mm), BS, 1118–1150 m (EMU-10436); St. 3 (23°9'N; 111°20'W), Aug 4, 2012, 1F (CL 36.4 mm), BS, 1395–1465 m (EMU-10433); St. 5C (23°16'42"N; 110°54'55"W), Aug 5, 2012, 8M (CL 20.5–35.5 mm), BS, 980–1036 m (EMU-10496-A); same station 25F (CL 20.3–40.5 mm), 1M (CL 13.4 mm), BS, 980–1036 m (EMU-10496-B); St. 5F (22°58'15"N; 110°40'17"W), Aug 5, 2012, 1F (CL 39.3 mm), BS, 1035–1108 m (EMU-10432); St. 8 (24°25'48"N; 112°38'6"W), Jul 30, 2012, 1M (CL 29.8 mm), 3F (CL 23.2–41.1 mm), BS, 1212–1235 m (EMU-10431); St. 24 (27°5'42"N; 114°35'30"W), Aug 1, 2012, 2F (CL 25–32.6 mm), BS, 772–786 m (EMU-10430).

TALUD XVI-B, St. 3 (28°42'36"N; 115°50'42"W), May 23, 2014, 2F (CL 30.1–31.0 mm), BS, 1350–1365 m (EMU-10623) St. 6 (29°08'9"N; 115°33'25"W), May 24, 2014, 10M (CL 16.4–29.9 mm) and 9F (CL 16.7–29.5 mm), BS, 1004–1102 m (EMU-10498); St. 8 (29°23'28"N; 115°45'W), May 31, 2014, 1M (CL 35.4 mm), 1F (CL 27 mm), BS, 1416–1480 m (EMU-10438); St. 16 (29°51'N; 116°9'W), May 29, 2014, 4F (CL 23.2–37.2 mm), BS, 1425–1360 m (EMU-10441); St. 23 (30°56'N; 116°40'33"W), May 27, 2014, 1M (CL 33.3 mm), 2F (CL 30.1–32.7 mm), BS, 1296–1340 m (EMU-10439); St. 26 (31°46'3"N; 116°58'12"W), May 26, 2014, 1F (CL 31.4 mm), BS, 982–989 m (EMU-10437); St. 27 (31°42'21"N; 117°13'W), May 27, 2014, BS, 1394–1397 m, 1F (CL 34.7 mm) (EMU-10440) and 1 F (CL 30.5 mm) (EMU-10497).

Size and sex. With 187 specimens available (61 males, CL 11.2–35.5 mm; 122 females, CL 16.7–53.3 mm; 3 unsexed; and 1 juvenile, CL 12.4) (M:F = 1:2), the collection of *B. tanneri* from off western Mexico came from 44 stations and is the largest available to date for this species (Figure 1). The largest specimens measured 103 mm (male; TALUD XV, St. 5C) and 116 mm (female; TALUD XII, St. 5) total length, the latter constituting the largest specimen collected to date. The size of individuals dif-

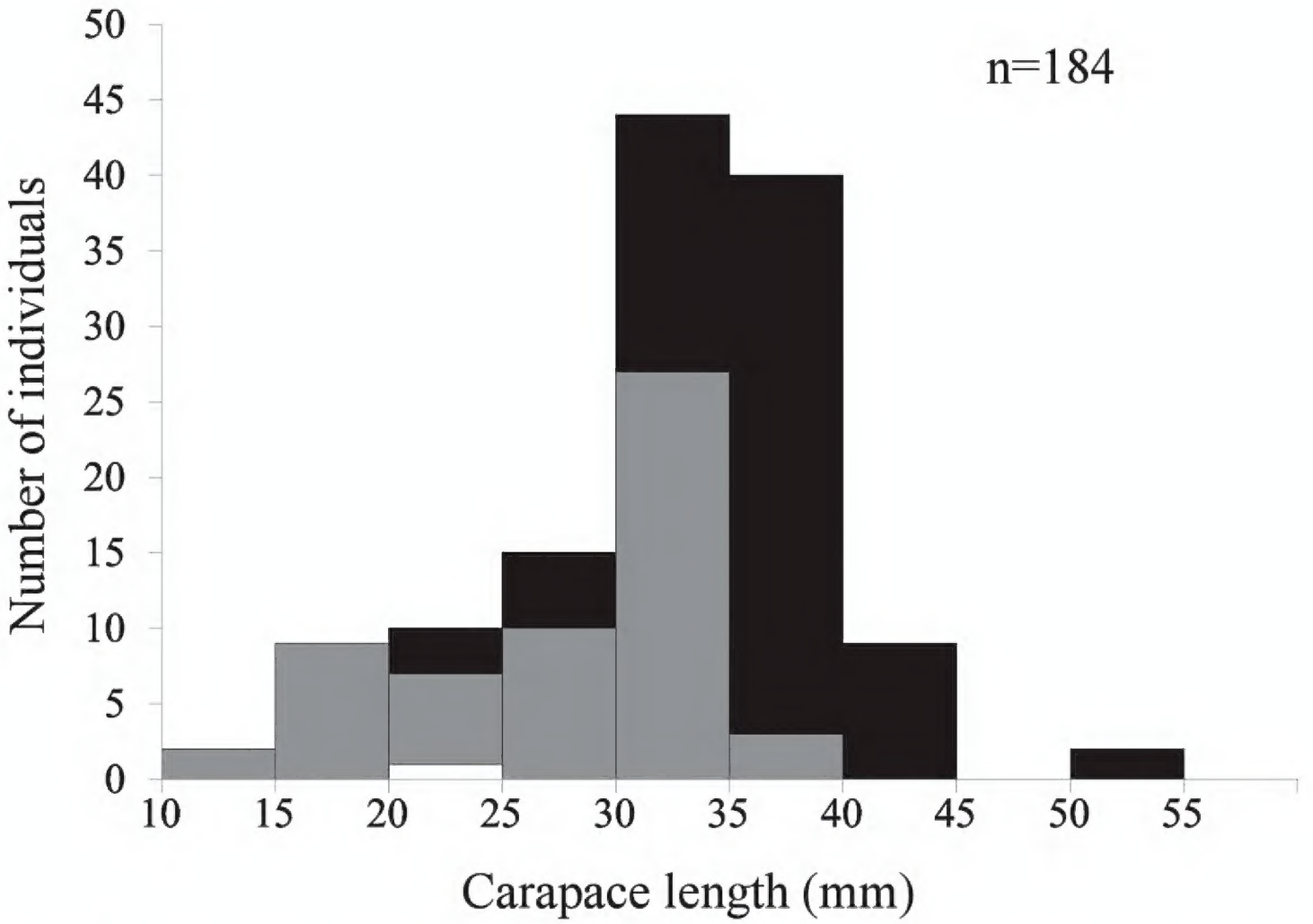


Figure 2. Carapace length distribution of *Benthesicymus tanneri* Faxon, 1893, by sex. White, juveniles; grey, males; black, females.

fered across sexes (Mann-Whitney *U* test, U=2058.00, p<0.001) with females growing larger than males (Figure 2).

Geographic and bathymetric distributions. The syntype series, collected by the "Albatross", contained 56 males and 78 females (134 specimens) from 22 lots captured over a wide latitudinal range (1°3'S to 27°34'N), and included material from 4 stations in Mexico: off Acapulco and Islas Tres Marías, and in the vicinity of Guaymas (Figure 1). We are not aware of further material collected off western Mexico.

According to Wicksten (1989), Retamal and Jara (2002) and Wicksten and Hendrickx (2003), *B. tanneri* is known from San Diego, California, USA, to Chile. The material currently examined slightly increases the distributional range of *B. tanneri* within the Gulf of California to the north, and indicates that *B. tanneri* occurs all along the west coast of the Baja California Peninsula where it had not been reported previously (Figure 1). In the Mexican Pacific it is a widely distributed and frequently captured species.

The material examined herein was collected between 750 and 2010 m depth with bottom sampling gear. One specimen (TALUD III, St. 17) was collected with a midwater trawl hauled from surface to 770 m depth, in a locality where total depth was 1560 m. All species of *Benthesicymus* occur in deep water and the general depth range for *B. tanneri* is 606–2422 m (Table 1) (Wicksten 1989).

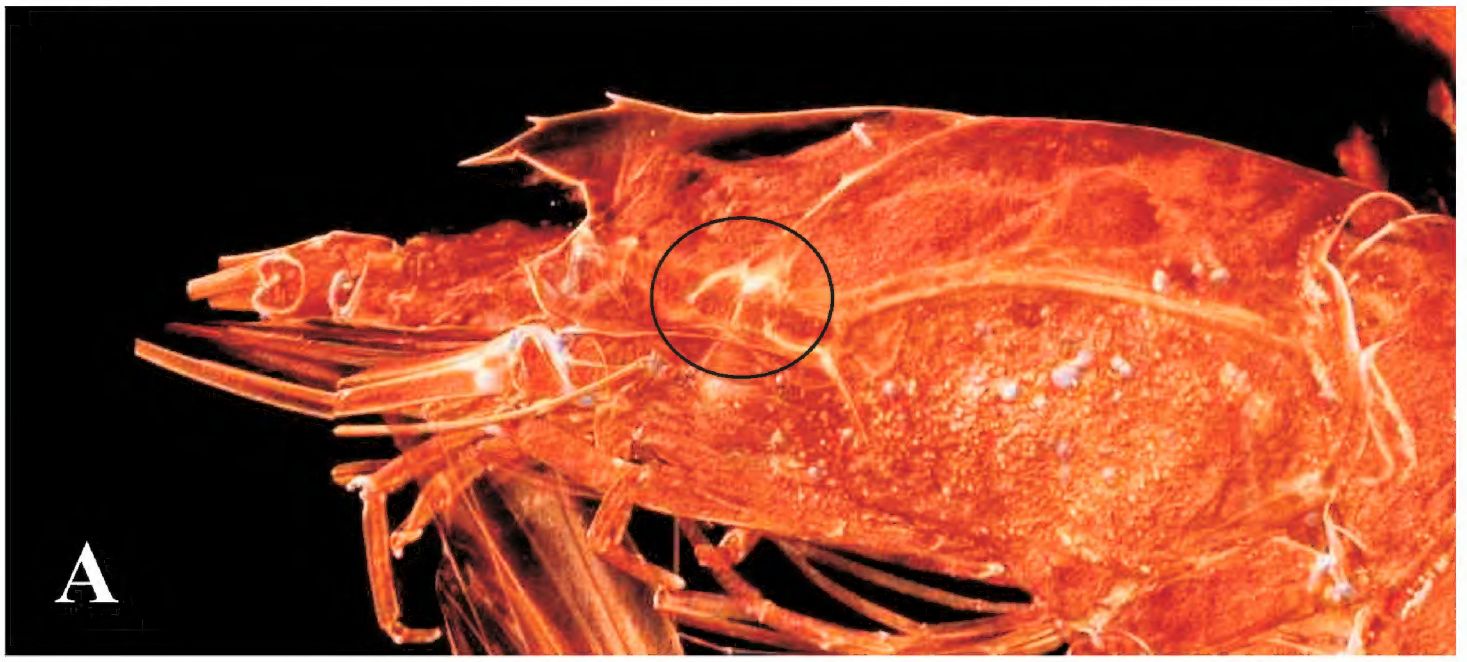
Table 1. Currently known distribution, depth range and maximum size for the species of *Benthesicymus* worldwide. Species list updated according to Fransen and De Grave (2014). MW, midwater trawl; BT, benthic trawl; IK, Isaac Kid midwater trawl; AT, Agassiz (benthic) trawl.

Species	Distribution	Depth range	Size	Source
Benthesicymus altus Spence Bate, 1881	Eastern, central and western Pacific; Atlantic and Indian Oceans	485 m (MW); 916–4089 m; 4130 m (BT)	CL 23.5 mm; TL 120 mm	Spence Bate 1881; Wicksten 1989; Kikuchi and Nemoto 1991, Guzman and Wicksten 2000; Wicksten and Hendrickx 2003
Benthesicymus armatus MacGilchrist, 1905	Arabian Sea	2753 m	TL 157 mm	MacGilchrist 1905
Benthesicymus bartletti S. I. Smith, 1882	Atlantic, eastern Indian and western Pacific Oceans	600–5777 m	CL 34.2 mm; TL 115 mm	Crosnier 1978; D'incao 1998; Tiefenbacher 2001
Benthesicymus brasiliensis Spence Bate, 1881	Atlantic, southern Pacific	600–4720 m	TL 152 mm	Spence Bate 1881; Tiefenbacher 2001
Benthesicymus cereus Burkenroad, 1936	Atlantic	1645–1727 m	CL 25 mm; TL 76 mm	Burkenroad 1936
Benthesicymus crenatus Spence Bate, 1881 (type species)	Northwestern and central Pacific	3530 m (BT); 3530–6350 m; 5469–9726 m	TL 200 mm	Spence Bate 1881; Komai and Komatsu 2009; Jamieson et al. 2009
Benthesicymus howensis Dall, 2001	Western Pacific	1325 m	CL 24.0 mm	Dall 2001
Benthesicymus investigatoris Alcock & Anderson, 1899	Indo-West Pacific; SW Pacific	0–1300 (IK); 1213 (AT); 580–1690 m	CL 27.5 mm; TL 89.5 mm	Kensley 1977; Kikuchi and Nemoto 1991; Dall 2001; Retamal and Moyano 2010
Benthesicymus iridescens Spence Bate, 1881	Atlantic Ocean	3890–6500 m	TL 150 mm; CL 47 mm	Spence Bate 1881; Crosnier 1985; Tiefenbacher 2001
Benthesicymus laciniatus Rathbun, 1906	Eastern Pacific	1471–3393 m	CL 42.6 mm	Wicksten 2004
Benthesicymus seymouri Tirmizi, 1960	Indian Ocean	1789–3716 m	CL 40–59 mm	Crosnier 1985; Pérez-Farfante and Kensley 1997
Benthesicymus strabus Burkenroad, 1936	Pacific Ocean	3530 m (BT)	CL 39.5 mm	Kikuchi and Nemoto 1991
Benthesicymus tanneri Faxon, 1893	Eastern Pacific	606–2422 m	TL 121 mm	Wicksten 1989; Wicksten and Hendrickx 2003; Hendrickx 2004
Benthesicymus tirmiziae Crosnier, 1978	Indian Ocean	1920–2249 m	33 mm CL, 100 mm TL	Crosnier 1978; Peréz-Farfante and Kensley 1997
Benthesicymus urinator Burkenroad, 1936	Indo-Pacific	1789–3716 m; 2500–4200 m; 4120 m (BT)	CL 25.0 mm	Crosnier 1985; Kikuchi and Nemoto 1991, Dall 2001

Of the 15 recognized species of *Benthesicymus* (Table 1), currently known distributions indicate that three are widespread (*B. altus*, *B. bartletti*, *B. investigatoris*), one occurs in both the Atlantic and part of the Pacific (*B. brasiliensis*), one is distributed in the Indo-Pacific (*B. urinator*), three are restricted to the Indian Ocean (or part of it) (*B. armatus*, *B. seymouri*, *B. tirmiziae*), five occur in the Pacific Ocean (*B. crenatus*, *B. howensis*, *B. strabus*, *B. laciniatus*, *B. tanneri*; the latter two only known from the eastern Pacific), and two are restricted to the Atlantic Ocean (*B. iridescens*, *B. cereus*).

On the presence of the hepatic spine in *B. tanneri*. In their identification key of Group II, Kikuchi and Nemoto (1991) indicated that *B. tanneri* possesses a hepatic spine, a character that separates this species from the other four species of their Group II. Guzmán and Wicksten (2000) emphasize that the presence of a hepatic spine was not mentioned in some of the previous literature referring to *B. tanneri* (i.e., Méndez 1981, Wicksten and Hendrickx 1992, Retamal and Soto 1993). Incidentally, the figure provided by Méndez (1981: fig. 62) does not show the presence of an hepatic spine but its reproduction in Hendrickx (1995) does (p. 437), which is an error due to the illustration process in the editorial office. In his preliminary description of *B. tanneri*, Faxon (1893) indicated that "*B. moratus*, Smith [S.-I. Smith, 1886, now recognized as a junior synonym of *B. brasiliensis* Spence Bate, 1881], another allied species [of *B. tanneri*], differs in having a distinct hepatic spine", from which it could be concluded that the type material of *B. tanneri* examined by Faxon (1893) lacks this spine. Re-description by Faxon (1895: 205) repeats essentially the same statement as in 1893, and his lateral illustration of the carapace (Plate H 1a) does not indicate the presence of a hepatic spine, although the lower extension of the cervical carina could easily be confused with a strong spine. Besides, this drawing does not include the presence of the pterygostomial spine either, which is definitively present in *B. tanneri* (see Burkenroad 1936: 52). Revision by Dr. Rafael Lemaitre of part of the material used by Faxon (1893, 1895) in his syntypic series and deposited at the National Museum of Natural History, Washington, DC (USNM 21214; syntypes from the Gulf of California, Mexico) confirms the fact that there is no trace of a hepatic spine on the specimens examined. Another revision by Adam Baldinger of one of the syntypes of *B. tanneri* (MCZ-4662) deposited at the Museum of Comparative Zoology at Harvard also clearly indicates the absence of a hepatic spine (Figure 3A). An illustration of a large specimen of *B. tanneri* collected during this survey is also provided for comparison (Figure 3B). References to this spine in earlier literature (Kikuchi and Nemoto 1991, Hendrickx 1995, Dall 2001) are therefore in error. Consequently, the groups definition presented by Kikuchi and Nemoto (1991) have to be altered because all species of Group II as defined by these authors in their key lack the hepatic spine which is otherwise present in seven of the ten species of their Group I. Moreover, the identification key proposed by Dall (2001) should be partly modified.

Reproductive organs. While studying fine morphology of *B. carinatus* (now included in *Altelatipes*), Tavares (2009) noted the lack of basic information related with the description and development of the reproductive organs of *Benthesicymus* s.l. The male petasma of *B. tanneri* was illustrated by Faxon (1895) and by Hendrickx and



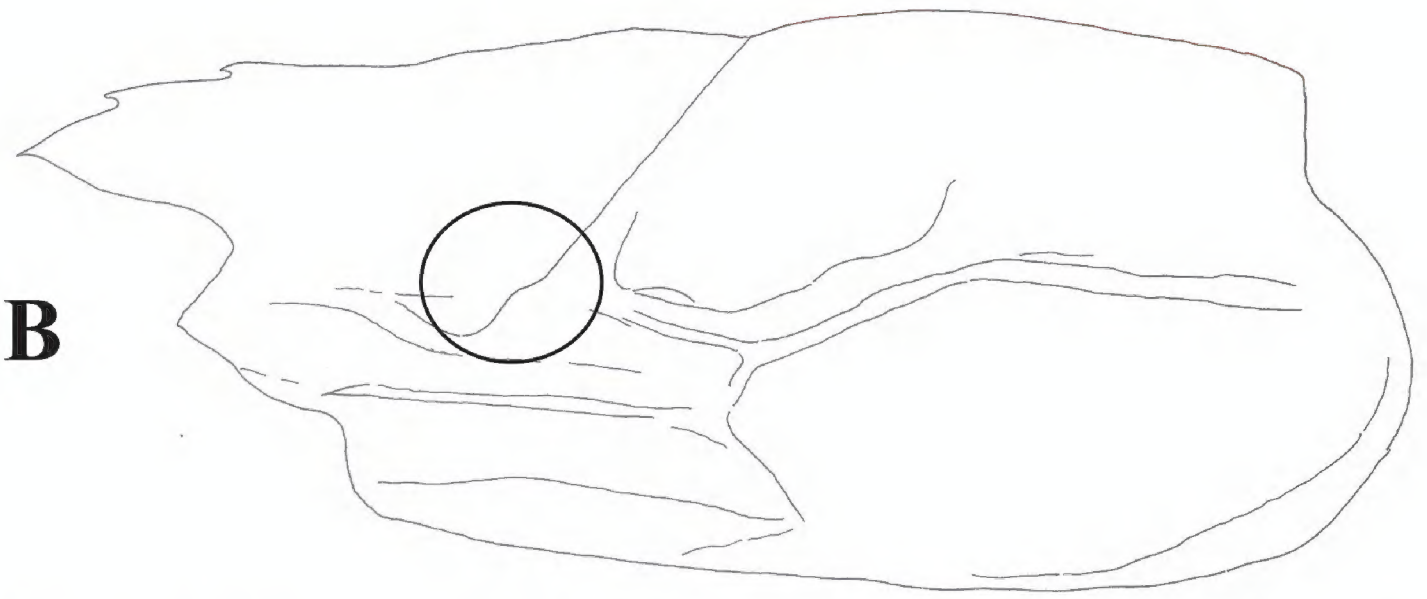


Figure 3. *Benthesicymus tanneri* Faxon, 1893. **A** Lateral view of syntypic specimen (MCZ-4662) **B** Lateral view of female (CL 40.6 mm) (EMU-10436). Circles indicate area where a hepatic spine is observed in some species of the genus.

Estrada-Navarrete (1996). Material examined collected in station 6 of the TALUD XVI-B cruise includes small and medium-size males with immature petasma (Figure 4A–D). The smallest male with visible petasma was 11.2 mm CL, in which a small bud without any elaborated structure could be seen. A slightly larger male (CL 16.4 mm) had a similar petasma (Figure 4D). However, another young male from station 19 of TALUD VII cruise with CL 11.2 mm (i.e., smaller than the male of Figure 4D) presented a relatively larger petasma (Figure 4E). The crescent-shape lateral process, which is typical of *B. tanneri*, is not yet developed in males of CL 17.5 mm (Figure 4C). In a male of CL 29.9 mm the two sections (left and right) of the petasma are well developed (Figure 4B) but not yet united medially.

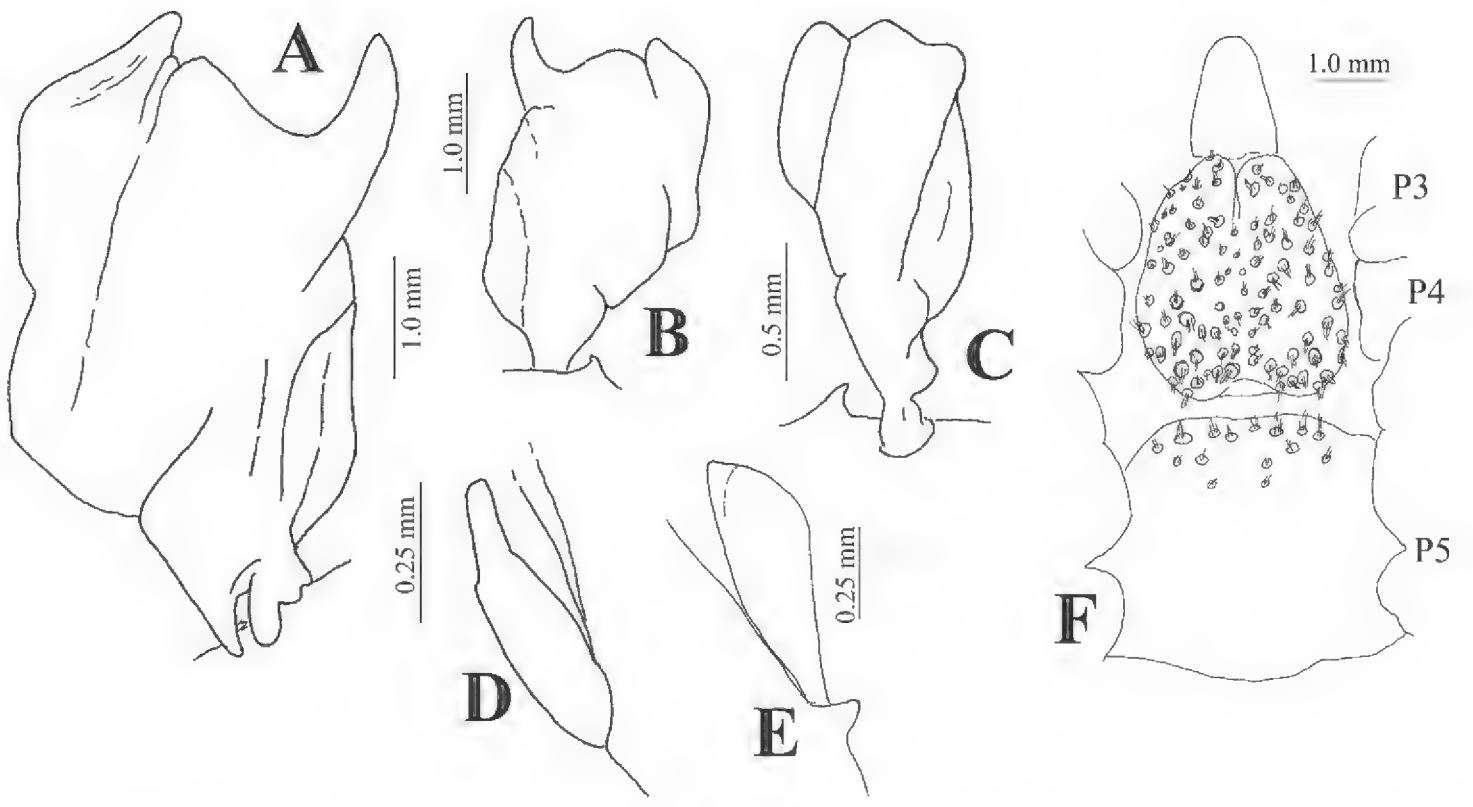


Figure 4. *Benthesicymus tanneri* Faxon, 1893. Anterior view of petasma (**A–E**) of males of different carapace length (**A–D** EMU-10498; **E** EMU-6004-A) and thelycum (**F**) of a mature female (EMU-10441). **A** CL 29.9 mm; **B** CL 22.3 mm; **C** CL 17.5 mm; **D** CL 16.4 mm; **E** CL 11.2 mm; **F** CL 36.6 mm.

The fully developed petasma (Figure 5A–D) of *B. tanneri* (CL ≥ 35 mm) is clearly distinct from known petasma of mature males of nine species of the genus in the presence of the lateral crescent-shape process. In *B. altus*, *B. brasiliensis*, *B. crenatus* (the type species of the genus), *B. investigatoris* Alcok & Anderson, 1899, *B. iridescens* Spence Bate, 1881, *B. laciniatus*, *B. seymouri* Tirmizi, 1960, *B. strabus* Burkenroad, 1936, and *B. urinator* Burkenroad, 1936, the petasma lacks the lateral crescent-shape process (see A. Milne Edwards and Bouvier 1909, Burkenroad 1936, Crosnier 1978, 1985, Hendrickx 1996, Kikuchi and Nemoto 1991) (see below for the case of *B. bartletti* S.I. Smith, 1882). It should be noted that figure 1, page 28, of Burkenroad (1936) is labeled "*Benthesicymus laciniatus* Rathbun", which is most certainly an error, and this illustration likely belongs to *B. crenatus*, as indicated earlier in the text by the author. Burkenroad (1936: fig. 35) also provided an illustration of the petasma of *B. cereus* Burkenroad, 1936, probably a juvenile. This figure lacks a lateral crescent-shape process but, as in the case of *B. tanneri* (see Figures 3, 4), this process may appear later during the growth of the species. Of the remaining three species of *Benthesicymus*, a crescent-like process has been described only in *B. tirmiziae* Crosnier, 1978 (but see below). The petasma of *B. howensis* Dall, 2001, remains undescribed as the species (originally described as a new subspecies of *B. urinator*) is known only from the two females of the type material. We were not able to locate an illustration of the petasma of *B. armatus* MacGilchrist, 1905. Another question remains open as far as illustrations of petasma in literature are concerned. Peréz-Farfante and Kensley (1997: fig. 27) provided an illustration of both the petasma and the thelycum of a species which certainly belongs to *Benthesicymus*; however, the figure caption is the same as the one inserted in figure

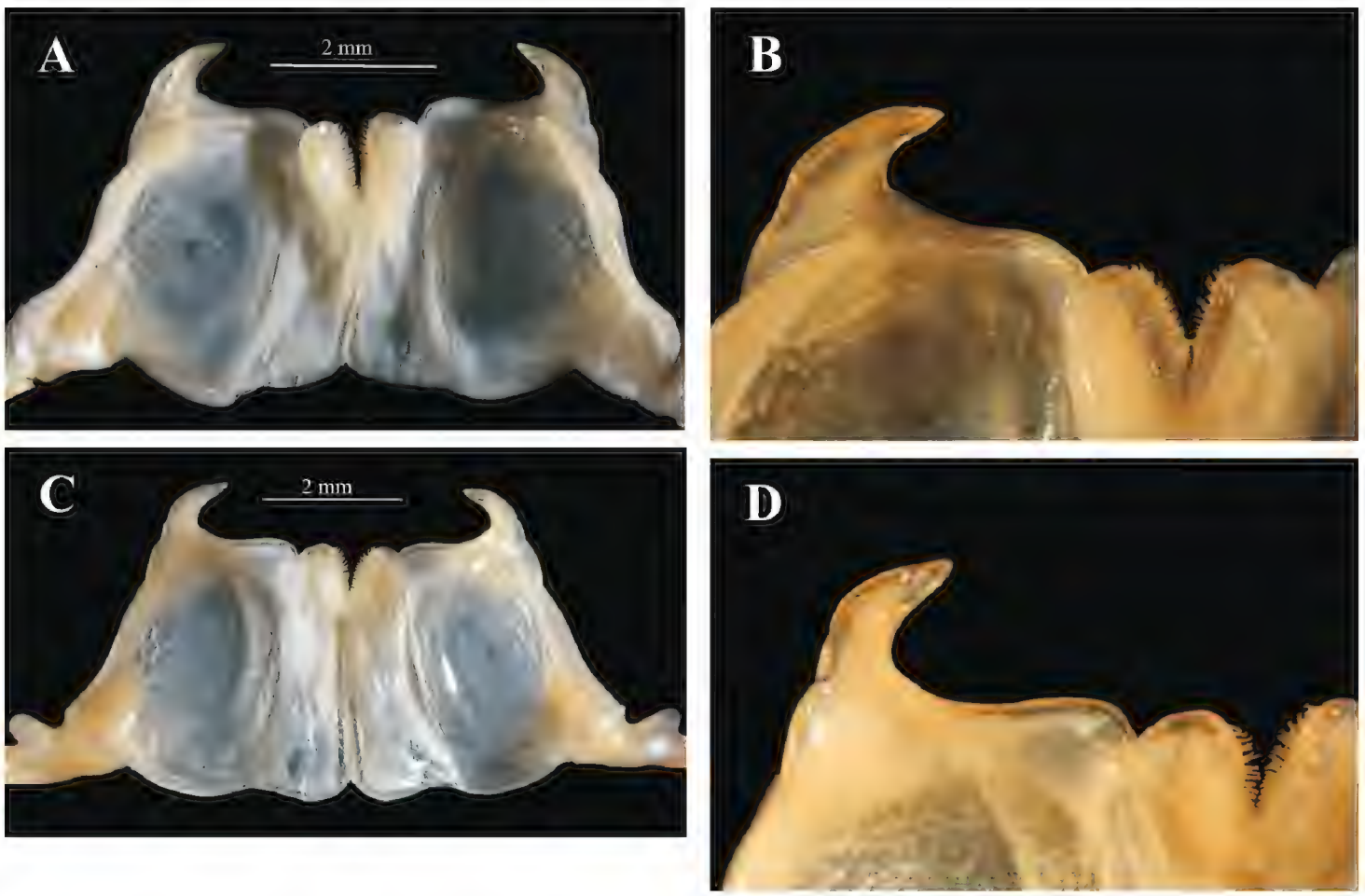


Figure 5. *Benthesicymus tanneri* Faxon, 1893. Petasma of a fully mature male (CL 35.7 mm) (EMU-8147) **A** Posterior view **B** Same, detail of ventral margin **C** Anterior view **D** Same, detail of ventral margin.

25 of the same monograph (i.e. for *Bentheogennema intermedia* (Spence Bate, 1888)) and it was therefore difficult to assess to which species of the genus this figure actually belongs to. A search by Rose Gulledge, Museum specialist at the US National History Museum, Smithsonian Institution crustacean department, Maryland, USA, was successful in finding the original plates prepared by the illustrator of Peréz-Farfante and Kensley (1997). Pencil markings and notes on the plates indicate that the petasma and thelycum of figure 27 belong to *Benthesicymus bartletti*, and that "species in book is wrong [...] must say *Benthesicymus bartletti*". Consequently, *B. bartletti* represents a third species featuring a crescent-shaped lateral process on the petasma, as *B. tanneri* and *B. tirmiziae* do.

The female thelycum of *B. tanneri* was roughly illustrated by Faxon (1895, plate H-1b) and is illustrated herein (Figure 4F). A small tuft of setae is clearly observed arising from each minute pit of the thelycum middle plate (sternite XIII). Of the two groups of species considered by Burkenroad (1936) in his synopsis of *Benthesicymus*, Group I possesses a "thelycum without well-defined receptacles between the twelfth and the thirteenth sternites, the scutes of the twelfth and thirteenth sternites being simple and unexpanded". Group II posseses "well-defined cavities between the twelfth and the thirteenth sternites, the scutes of the thirteenth sternites being broadly expanded to overlap the sternal surface proper". Based on these criteria *B. tanneri* belongs to Group II, with the scutes of sternite XIII broadly expanded (Figure 4F).

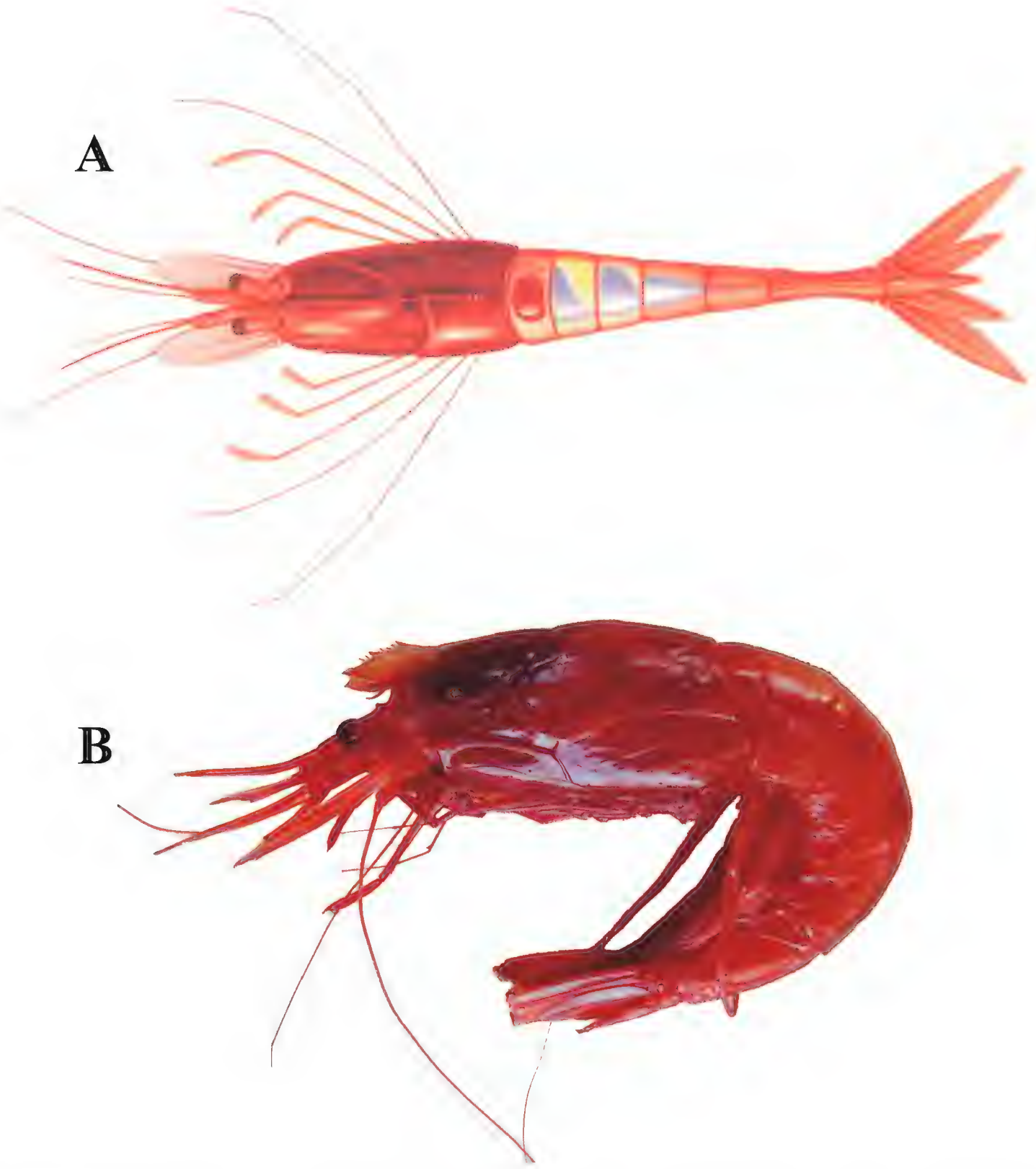


Figure 6. *Benthesicymus tanneri* Faxon, 1893. **A** Dorsal view of one of the syntypes used by Faxon (1893) (from Faxon 1895) **B** Fresh specimen female, CL 30 mm, lateral view (EMU-8904).

Color. The color of fresh specimens was described by Faxon (1895: 207) and a color drawing (Plate H-1) was added to his contribution (reproduced here as Figure 6A). All specimens collected during the TALUD survey presented the typical "deep red" color (Figure 6B) described by Faxon (1895). The large patch of bright blue color on the back of the abdominal somites 2–4 mentioned by Faxon (op. cit.) and also observed by Moscoso (2012) actually corresponds to the gonads of mature specimens that extend backward from the thoracic area (pers. observ.).

Fishery resource. Although it reaches a size (i.e., over 115 mm total length) comparable with other species of Dendrobranchiata used as food, *B. tanneri* is not currently subject to any commercial exploitation. It has been considered a potential fisheries resource for the area (see Hendrickx 1995) to a large extent because it occurs together with other species of established potential for deep-water fisheries (e.g., *Heterocarpus affinis* Faxon, 1893, *Haliporoides diomedeae* Faxon, 1893) (Barriga et al. 2009). Since 2004, the Peru fishery program has included *B. tanneri* in a short list of sub-exploited deep-water shrimps subject to "exploratory fishing" in Peruvian waters (Ministerio de la Producción 2004). In the specific case of the western central Pacific, Chan (1998) reported the presence of six species of *Benthesicymus* in this area, but none was considered of importance to fishery, even as a potential resource, probably because this genus has nowhere been reported to be abundant. The 15 species of *Benthesicymus* known to date are from mid-sized (from ca 70–80 mm TL) to large (ca 200 mm TL) (Table 1) but are all from deep-water, thus rending any exploitation attempt very complex.

Key to the species of *Benthesicymus* from the eastern Pacific

1a Posterolateral margin of fifth abdominal somite with small spines.... ***B. laciniatus***

1b Posterolateral margin of fifth abdominal somite without spines **2**

2a Petasma ventral margin strongly convex, without lateral crescent-shape process. Thelycum sternite XIII plate smooth, without small pits and setae..... ..... ***B. investigatoris***

2b Petasma ventral margin straight to slightly concave, with or without lateral crescent-shape process. Thelycum sternite XIII plate bearing small pits..... **3**

3a Petasma with strong ventrolateral crescent-shape process. Thelycum sternite XIII plate longer than wide, shallow anterior notch ..... ***B. tanneri***

3b Petasma without ventrolateral crescent-shape process. Thelycum sternite XIII plate wider than long, deep anterior notch..... ***B. altus***

Ackowledgments

Ship time was provided by the Instituto de Ciencias del Mar y Limnología, UNAM (TALUD III), by the Coordinación de la Investigación Científica, UNAM (TALUD IV-XVI-B), and partly supported by CONACyT (project 179467 for the TALUD XV and XVI-B cruises). The TALUD project has received laboratory and field work support from the DGAPA (PAPIIT IN-217306–3 and PAPIIT IN-203013–2) and from CONACyT (Project 31805-N for the TALUD IV-VII cruises; project 179467 for the TALUD XV and XVI-B cruises), Mexico. The authors thank all scientists, students and crew members who took an active part in the TALUD cruises. We also thank Dr. Rafael Lemaitre, National Museum of Natural History, Maryland, USA, for revising type material of *B. tan-*

neri deposited in the USNM and providing useful information on its morphology, and Adam Baldinger, Museum of Comparative Zoology at Harvard, Massachussets, USA, for providing the photograph in Figure 3A. We thank Raymond Bauer for contacting Rose Gulledge, National Museum of Natural History, Maryland, USA, who kindly provided scanned images of the original material used in figure 27 of Pérez-Farfante and Kensley (1997) monograph. Mercedes Cordero Ruiz is acknowledged for preparing Figure 3, and editing Figures 1–2 and the final version of the manuscript. We also thank Ana K. Barragán (SNI III assistant, CONACyT) for her help with laboratory work during this study and José Salgado B. for photograph of Figure 6 B. Work by Vanesa Papiol was supported by a DGAPA, Universidad Nacional Autónoma de México, postdoctoral grant.

References

Barriga E, Salazar C, Palacios J, Romero M, Rodríguez A (2009) Distribución, abundancia y estructura poblacional del langostino rojo de profundidad *Haliporoides diomedeae* (Crustacea: Decapoda: Solenoceridae) frente a la zona norte de Perú (2007–2008). Latin America Journal of Aquatic Research 37(3): 371–380.

Burkenroad M (1936) The Aristaeinae, Solenocerinae and pelagic Penaeinae of the Bingham Oceanographic Collection. Bulletin of the Bingham Oceanographic Collection 5(2): 1–151.

Chan T-Y (1998) Shrimps and prawns In: Carpenter KE, Niem VH (Eds) The living marine resources of the western central Pacific. Vol. 2. Cephalopods, crustaceans, holothurians and sharks. FAO, Roma, 852–971.

Cornejo-Antepara M (2010) Los crustáceos decápodos de aguas profundas del mar ecuatoriano. Master Thesis, Universidad de Guayaquil, Facultad de Ciencias Naturales, Guayaquil, Ecuador.

Crosnier A (1978) Crustacés décapodes Pénéides Aristeidae (Benthesicyminae, Aristeinae, Solenocerinae). Faune de Madagascar. ORSTOM, CNRS (Paris) 46: 1–197.

Crosnier A (1985) Crevettes pénéides d'eaux profondes récoltées dans l'océan Indien lors des campagnes BENTHEDI, SAFARI I et II, MD 32/REUNION. Bulletin du Muséum National d' Histoire Naturelle, Paris (4) 7, section A, 4: 839–877.

Dall W (2001) Australian species of Aristeidae and Benthesicymidae (Penaeoidea: Decapoda). Memoirs of the Queensland Museum 46(2): 409–441.

De Grave S, Fransen CHJM (2011) Carideorum catalogus: the recent species of the dendrobranchiate, stenopodidean, procarididean and caridean shrimps. Zoologische Mededelingen, Leiden 85: 195–588.

D'Incao F (1998) The Brazilian species of the family Aristeidae Wood-Mason (Crustacea: Decapoda). Journal of Natural History 32: 1509–1518. doi: 10.1080/00222939800771041

Faxon W (1893) Reports on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U.S. Fish Commission steamer "Albatross", during 1891, lieut. Commander Z.L. Tanner, U.S.N., commanding. VI. Preliminary descriptions of new species of Crustacea. Bulletin of the Museum of Comparative Zoology at Harvard University 24 (7): 149–220.

Faxon W (1895) Reports on an exploration off the west coast of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, carried on by the U.S. Fish Commission steamer "Albatross", during 1891, lieut. Commander Z.L. Tanner, U.S.N., commanding. XV. The stalk-eyed Crustacea. Memoirs of the Museum of Comparative Zoology at Harvard College 18: 1–292.

Fransen C, De Grave S (2014) *Benthesicymus* Spence Bate, 1881. Accessed through: World Register of Marine Species at http://www.marinespecies.org/aphia.php?p=taxdetails&id=106811 [2014–12–09]

Guzman G, Wicksten MK (2000) The subfamily Benthesicyminae Bouvier, 1908 (Decapoda, Dendrobranchiata) in northern Chile (18° to 22°S). Crustaceana 73(8): 925–931. doi: 10.1163/156854000504985

Hendrickx ME (1993) Crustáceos Decápodos del Pacífico Mexicano. In: Salazar-Vallejo SI, González EN (Eds) Biodiversidad Marina y Costera de México. Comisión Nacional de Biodiversidad and CIQRO, Mexico, DF, 271–318.

Hendrickx ME (1995) Camarones. In: Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE, Niem VH (Eds) Guía FAO para la identificación de especies para los fines de la pesca. Pacífico centro-oriental. Vol. I. Plantas e Invertebrados. FAO, Roma, 417–537.

Hendrickx ME (1996) Los camarones Penaeoidea bentónicos (Crustacea: Decapoda: Dendrobranchiata) del Pacífico mexicano. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad e Instituto de Ciencias del Mar y Limnología, UNAM, México, DF, 148 pp.

Hendrickx ME (2001) Occurrence of a continental slope decapod crustacean community along the edge of the minimum oxygen zone in the southeastern Gulf of California, Mexico. Belgian Journal of Zoology 131 (Suppl. 2): 95–109.

Hendrickx ME (2004) Distribution and estimation of body size and weight of four species of deep water shrimps in the SE Gulf of California, Mexico. Crustaceana 76 (9): 1025–1036.

Hendrickx ME, Estrada-Navarrete FD (1996) Los camarones Pelágicos (Crustacea: Dendrobranchiata y Caridea) del Pacífico mexicano. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad e Inst. Cienc. Mar y Limnol., UNAM, México, DF, 157 pp.

Jamieson AJ, Fujii T, Solan M, Matsumoto AK, Bagley PM, Priede IG (2009) First findings of decapod crustacea in the hadal zone. Deep-Sea Research I 56: 641–647. doi: 10.1016/j.dsr.2008.11.003

Kameya A, Castillo R, Escudero L, Tello E, Blaskovic V, Córdova J, Hooker Y, Gutiérrez M, Mayor S (1997) Localización, distribución y concentración de langostinos rojos de profundidad Crucero BIC Humboldt 9607–08. 18 de julio a 06 de agosto de 1996. Publicación Especial, Instituto del Mar de Perú, 47 pp.

Kensley B (1977) The South African Museum's Meiring Naude cruises. Part 5. Crustacea, Decapoda, Reptantia & Natantia. Annals of the South African Museum 74(2): 13–44.

Kikuchi T, Nemoto T (1991) Deep-sea shrimps of the genus *Benthesicymus* (Decapoda: Dendrobranchiata) from the western north Pacific. Journal of Crustacean Biology 11(1): 64–89. doi: 10.2307/1548545

Komai T, Komatsu H (2009) Deep-sea shrimps and lobsters (Crustacea: Decapoda) from Northern Japan collected during the project "Research on Deep-sea fauna and pollutants

off Pacific coast of Northern Japan". In: Fujita T (Ed.) Deep-sea Fauna and Pollutants off Pacific coast of Northern Japan. National Museum of Nature and Science Monographs 39: 495–580.

MacGilchrist AC (1905) XXVII. Natural History Notes from the R.I.M.S. 'Investigator,' Capt. T. H. Henning, R. N. (retired), commanding. Series III., No. 6. An Account of the new and some of the rarer Decapod Crustacea obtained during the Surveying Seasons 1901–1904. The Annals and Magazine of Natural History, Series 7, 15(87): 234–268.

Mann HB, Whitney DR (1947) On a test of whether one of two random variables is stochastically larger than the other. Annals of Mathematical Statistics 18(1): 50–60. doi: 10.1214/aoms/1177730491

Méndez M (1981) Claves de identificación y distribución de los langostinos y camarones (Crustacea: Decapoda) del mar y ríos de la costa del Perú. Boletín del Instituto del Mar de Perú 5: 1–170.

Milne-Edwards A, Bouvier EL (1909) Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico (1877–78), in the Caribbean Sea (1878–79), and along the Atlantic coast of the United States (1880), by the U.S. Coast Survey Steamer "Blake", Lieut.-Com. C.D. Sigsbee, U.S.N., and Commander J.R. Bartlett, U.S.N., commanding. 44. Les Pénéides et Sténopides. Memoirs of the Museum of Comparative Zoology at Harvard College 27(3): 177–274.

Ministerio de la Producción (2004) Resolución Directorial 174–2004-Produce/DNEPP. www2.produce.gob.pe/dispositivos [Consulted in October 2014]

Moscoso V (2012) Catálogo de crustáceos decápodos y estomatópodos del Perú. Boletín del Instituto del Mar del Perú 27 (1–2): 1–208.

Peréz-Farfante I, Kensley B (1997) Penaeoid and sergestoid shrimps and prawns of the world. Keys and diagnoses for the families and genera. Mémoirs du Muséum national d'histoire naturelle 175: 1–233.

Rathbun MJ (1904) Decapod crustaceans of the northwest coast of North America. Harriman Alaska Expedition 10: 1–190.

Retamal M, Soto R (1993) Crustáceos decápodos abisales de la zona Arica, Iquique. Estudios Oceanológicos 12: 1–8.

Retamal MA, Jara C (2002) La Carcinología en Chile. In: Hendrickx ME (Ed.) Contributions to the Study of East Pacific Crustaceans 1 [Contribuciones al Estudio de los Crustáceos del Pacífico Este 1]. Instituto de Ciencias del Mar y Limnología, UNAM, México, DF, 195–208.

Retamal MA, Moyano HI (2010) Zoogeografía de los crustáceos decápodos chilenos marinos y dulceacuícolas. Latin America Journal of Aquatic Research 38(3): 302–328.

Rodríguez de la Cruz MC (1987) Crustáceos Decápodos del Golfo de California. Secretaria de Pesca, México, DF, 305 pp.

Schmitt WL (1921) The marine decapod Crustacea of California with special reference to the decapod Crustacea collected by the United States Bureau of Fisheries Steamer "Albatross" in connection with the biological survey of San Francisco Bay during the years 1912–1913. University of California Publications in Zoology 23: 1–470.

Spence Bate C (1881) On the Penaeidea. Annals and Magazine of Natural History 5(8): 169–196.

Tavares C (2009) New record of *Benthesicymus carinatus* Smith, 1884 (Decapoda: Benthesicymidae), with some notes on its morphology deduced from SEM observations. Cahiers de Biologie Marine 50(2): 199–205.

Tiefenbacher L (2001) Recent samples of mainly rare decapod crustacea taken from the deep-sea floor of the southern west Europe basin. Hydrobiologia 449: 59–70. doi: 10.1023/A:1017524600732

Vargas R, Wehrtman IS (2009) Decapod Crustaceans. Part 16. In: Wehrtmann IS, Cortés J (Eds) Marine Biodiversity of Costa Rica, Central America. Monographiae Biologicae 86, Springer Science, 209–236.

Wicksten MK (1989) Ranges of offshore decapod crustaceans in the eastern Pacific Ocean. Transactions of the San Diego Society of Natural History 21(19): 291–316.

Wicksten MK (2004) The status of *Benthesicymus laciniatus* Rathbun (Decapoda, Penaeoidea, Benthesicymidae) in the Northeastern Pacific. Bulletin of the Southern California Academy of Sciences 103(2): 93–94.

Wicksten MK, Hendrickx ME (1992) Checklist of Penaeoid and Caridean shrimps (Decapoda: Penaeoidea, Caridea) from the eastern tropical Pacific. Proceeding of the San Diego Society of Natural History 9: 1–11.

Wicksten MK, Hendrickx ME (2003) An updated checklist of benthic marine and brackish water shrimps (Decapoda: Penaoidea, Stenopodidea, Caridea) from the Eastern Tropical Pacific. In: Hendrickx ME (Ed.) Contributions to the Study of East Pacific Crustaceans 2. [Contribuciones al Estudio de los Crustáceos del Pacífico Este 2]. Instituto de Ciencias del Mar y Limnología, UNAM, México, DF, 49–76.